Space Weather Technical Forecast

Issued on Friday, 21 January 2022 at 01:20 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Slight chance G1/Minor Storm intervals from CME arrivals throughout. S1/Minor solar radiation storm has occurred. Solar activity has been High. Active high energy electron fluence.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: There are five numbered sunspots containing active regions on the Earth-facing disc, although AR2929 and AR2930 will soon rotate behind the western limb. Solar activity reached High levels as AR2929 (Dso/Beta-gamma) produced an M5 flare at 20/0601 UTC. An associated CME followed soon after, and has been analysed to miss Earth. A filament eruption from the southwest quarter, around 20/0800-0830 UTC, also produced a CME, and this CME may produce glancing impacts to Earth on the day 4 (24th).

The remaining spots groups showed little activity, or changes in complexity. AR2930 (Dsi, Beta) is the next largest, and modestly complex group. AR2927 Axx/Alpha and AR2933 Cao/Beta are small regions, lying the southwest quadrant. AR2934 (Hsx/Alpha) continues to rotate into the southeast quadrant from the southeast limb.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR and ACE at L1 was mainly between 460-500 km/s, peaking at 536 km/s at 20/0216 UTC. Density was at mostly average levels, until the evening, then decreasing to below average levels to end the day. The total interplanetary magnetic field strength (IMF), Bt, was weak 4-6nT. The north-south component weakly variable +4nT to -1nT. Phi angle was negative (toward the Sun) throughout. Geomagnetic activity was Quiet to Unsettled (Kp 0-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) measured at GOES 16, increased following the M5 flare with the S1 level being exceeded between around 20/0800-1605 UTC, with a peak of 23pfu at 20/1015 UTC. The 100MeV proton flux also rose above the 1pfu level between 20/0720-1105 UTC. High energy electron flux (greater than 2MeV) measured at GOES 16 was at mostly High levels, with a peak value of 2.66e3 pfu at 20/1655 UTC. Electron fluence persisted above the 1e8 Active threshold, with a generally steady trend and an observation value of 1.32e8 integrated pfu recorded at 21/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: There continues to be a slight chance of further isolated M-class flares as AR2929 rotates off the west limb today. From tomorrow the risk decreases, with AR2929 further behind the western limb. Thereafter Very Low or Low solar activity is expected, barring any new sunspot development elsewhere on the visible disc, as no new significant regions are expected to rotate onto the visible disc.

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Solar Wind / Geomagnetic Activity: There are three potential CME arrivals through the period; there is a chance of a glancing impact either late today (21st) or early tomorrow (22nd) from the CME from the M-class flare on the 19th. Another CME, generated by the filament eruption in the southwest quadrant yesterday, may brush Earth with limited impacts on day 4 (24th). However, confidence is low regarding these CMEs, with the bulk of the material each time likely to pass ahead and to the north of Earth. A further slower, and weak CME which occurred on the 19th has the potential to arrive day 3 (23rd), with confidence slightly higher for some limited impacts at Earth. Geomagnetic activity is forecast to be mostly Quiet to Unsettled (Kp 0-3), but a slight chance of increasing Active to G1/Minor storm (Kp 4-5) levels from any CME arrival.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is forecast to slowly decrease back to background levels through the next two days. The high energy electron flux (greater than 2MeV) is expected to be continue to at mainly High flux levels throughout the period, but any CME arrival is likely to bring a noticeable dropout with mainly Moderate, perhaps peak high flux levels following. The 24-hour fluence is forecast to persist above the Active threshold, but with an increasing chance of dropping below this level by the end of the period.

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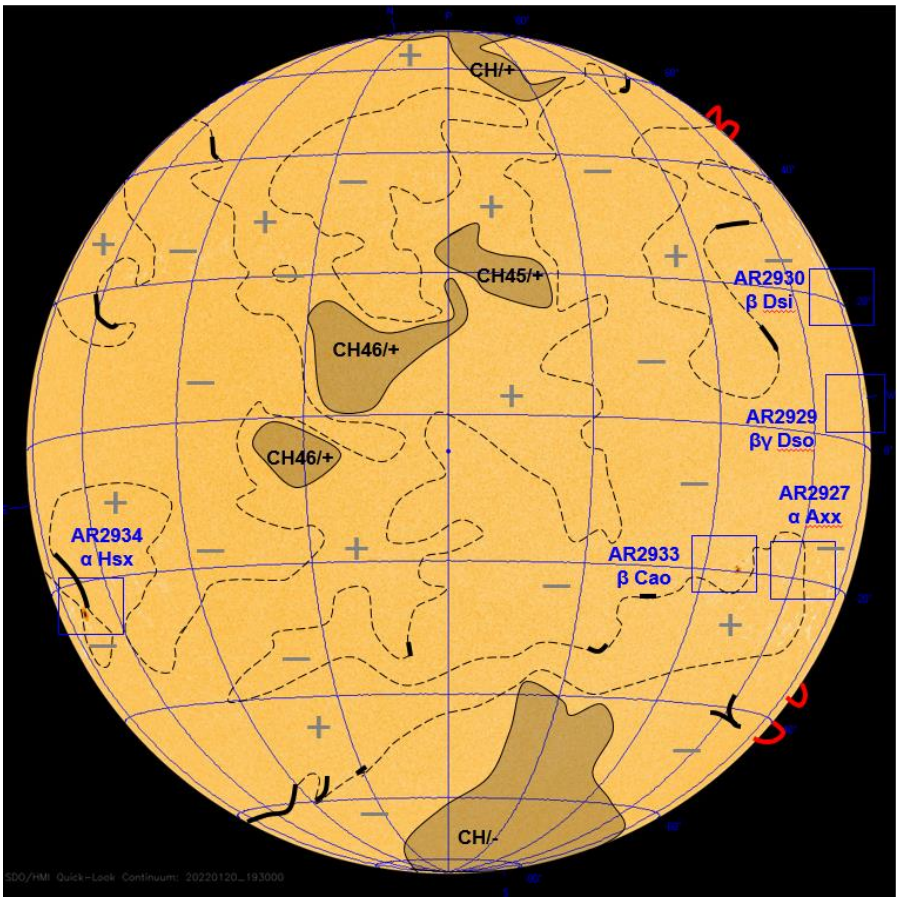
Figure 1. Solar Analysis Valid 20/1930 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are a number of CMEs that have left the Sun over the past few days which may have Earth-directed components:
A CME has the potential to give a glancing impact either late today or early tomorrow (21st or 22nd), generated from the M1.5 flare of AR2929. Another CME, associated with a filament eruption in the southwest quadrant yesterday, may brush Earth with limited impacts on day 4 (24th). However, confidence is low regarding these CMEs, with the bulk of the material each time likely to pass ahead and to the north of Earth. A further slower, and weak CME which occurred on the 19th has the potential to arrive day 3 (23rd), with confidence slightly higher for some limited impacts at Earth.
A third Earth-directed CME was observed primarily on STEREO A but also very faintly on SOHO LASCO on the 19th. This is from a large filament that weakly lifted around 19/0200 UTC. Unlike the previous CMEs, this is a less energetic lift, but from a more conducive location for moving across Earth. Due to its weaker nature, confidence is lower on potential impacts, however, with increased confidence for this to move across Earth, a slight chance of G1/Minor Storm intervals is maintained for day 4 (23rd).

Otherwise the solar wind is expected to be at background to slightly elevated levels, due to a small northward extension of the southern polar coronal hole possibly connecting to Earth from tomorrow and day 3 (22nd and 23rd) and then potentially a weak HSS from small CH45 becoming geoeffective through day 4 (24th). Geomagnetic activity is forecast to be mostly Quiet to Unsettled (Kp 0-3), but a slight chance of increasing Active to G1/Minor storm (Kp 4-5) levels any day, due to a combination of CME arrival or weak HSS influences.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	20	20	20	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
18/2140	Partial	M1.5 flare of AR2929	58W 11N	950	22/0000	Bulk missing – only weak sideswipe
19/1837	Partial	Filament	17W 16S	288	23/1500	Low confidence with fit.
20/1642	Partial	Filament	59W 2S	478	24/1200	Likely to pass north of Earth

Figure 2: Met Office Enlil ensemble forecast, showing potential CME arrival each day.

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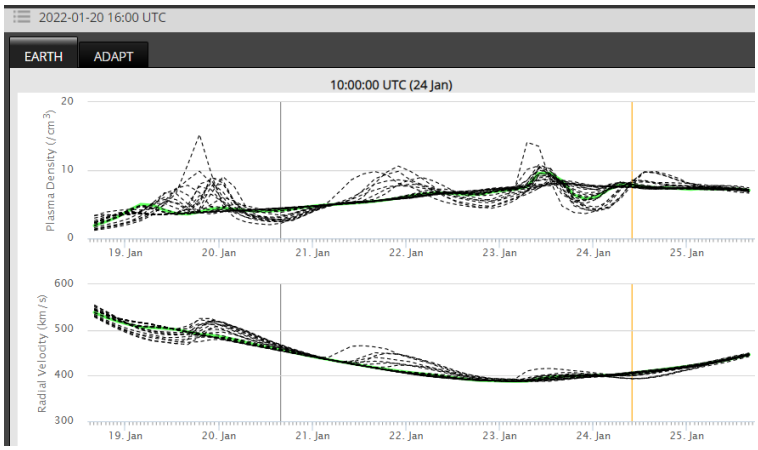

Radio Blackouts - X-Ray Flares:

There are five numbered sunspot regions on the disc. AR2929 and AR2930 are now on the western limb, and so hard to assess. The former produced an M5 flare at 20/0601 UTC indicating continuing complexity, and also a B6.9 just at the end of the period yesterday. AR2933 is a small bipolar region which has elongated slightly, but otherwise not changed recently. AR2927 remains a simple alpha spot, whilst AR2934 (Hsx/alpha) continues to rotate into a clearer view towards the southeast limb. There continues to be a slight chance of further isolated Moderate flares as AR2929 rotates around the west limb, however this risk should diminish through the period, barring any new sunspot development elsewhere on the visible disc.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	10	5	1	1
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: GOES-16 and GOES-17 X-ray flux for the past 24 hours.

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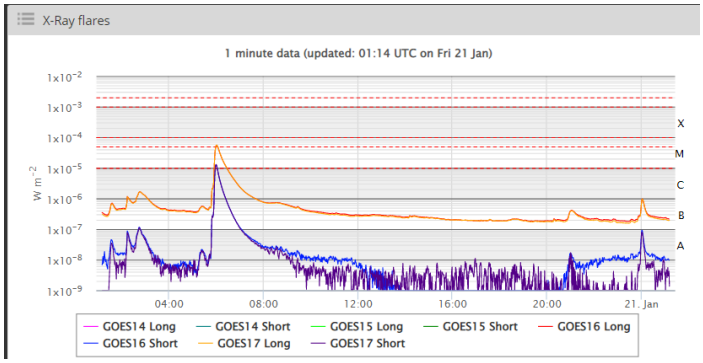
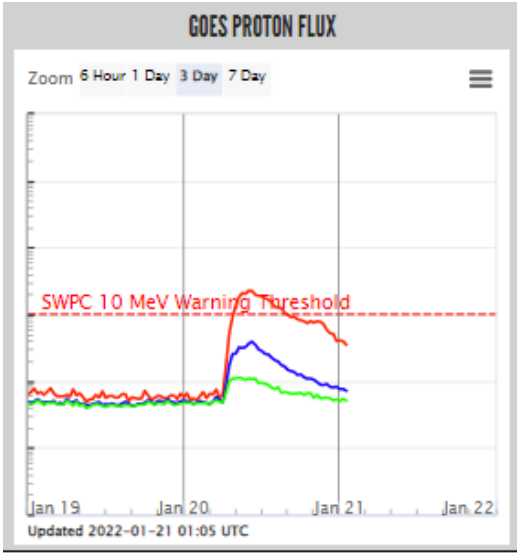


Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) measured at GOES 16, increased following the M5 flare with the S1 level being exceeded between around 20/0800-1605 UTC, with a peak of 23pfu at 20/1015 UTC, and is currently at moderate levels. The 100MeV proton flux also rose above the 1pfu level between 20/0720-1105 UTC. The high energy (greater than 10 MeV) proton flux is forecast to slowly decrease back to background levels through the next two days.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	10	5	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-16 High Energy Proton Flux



High Energy Electrons Event (≥ 2MeV):

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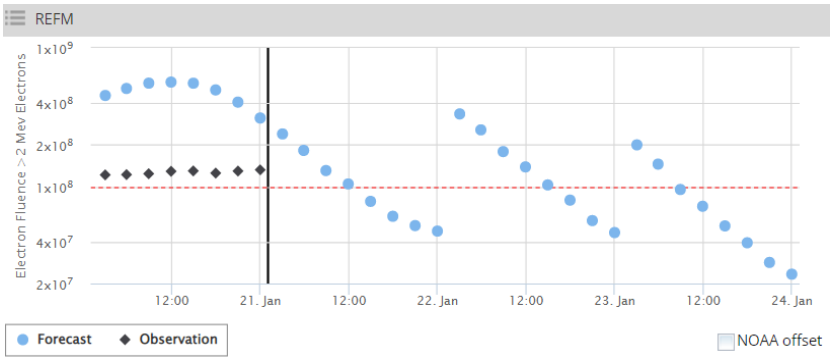
The high energy (greater than 2 MeV) electron flux, as measured by GOES-16 at GEO, is currently High after recent fast wind and CME enhancements. In the absence of any CME arrivals, these high levels would be expected to persist for much of the period, with just a gradual declining trend. However there is a chance that any CME that does glance across the Earth will bring a noticeable dropout, with levels falling to background and perhaps only recovering to Moderate with peak High levels. There are three potential such CME arrivals; late today or early tomorrow, then during days 3 and 4 (23rd and 24th).

The associated fluence is currently Active (above 1e8 integrated pfu) and expected to persist at this level, but with an increasing chance of falling below due to any flux drop out that occurs, and likely falling below later day 4 (24th) with the arrival of the third CME. The Met Office REFM model has initially fluence values too high, compared to observed values, and with a declining trend that is considered too fast.

GEO Electron Environment	Level ($cm^{-2}\,sr^{-1}\,day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	100	80	60	40
Very Active	≥ 2 MeV ≥ $1x10^9$	No	10	5	1	1

Figure 5: Met Office REFM Model.



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